DOI/GO-102001-1165
NREL/BK-710-29267
May 2001

5.8.8 Combined Heat and Power

Combined heat and power, or CHP, is the joint production of both heat (usually steam or hot water) and electricity from a single fuel source. Conventional U.S. power production converts roughly one-third of the Btu from the primary energy source (e.g., coal or natural gas) into electricity; most of the rest is lost as waste heat. Collecting and making productive use of that waste heat can result in total efficiencies over 70%. Combined heat and power is often referred to as *cogeneration*. Many commercial CHP systems go even further, producing electricity, steam, and chilled water from the heat. This is often referred to as *trigeneration.*

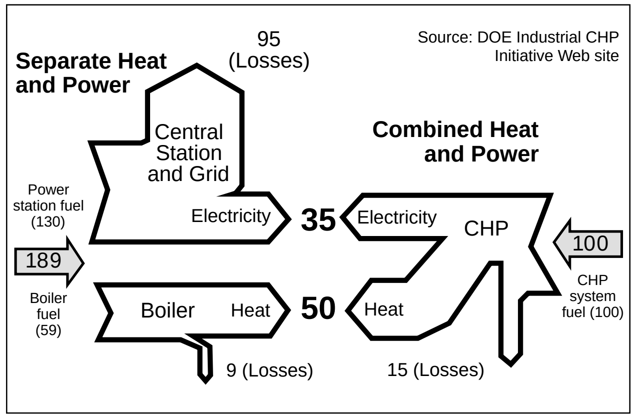
Opportunities

Combined heat and power systems can be implemented on many different levels. At the largest scale, utility power production can be developed in such a way that cogenerated steam is distributed to nearby energy users through a district energy system. Such CHP systems are operating successfully in Boston, Philadelphia, Trenton, St. Louis, and Oklahoma City. In Philadelphia, for example, a CHP plant produces up to 150 MW of electricity while providing steam for 375 district-heating customers that include 70% of the city's downtown commercial buildings and institutional facilities. At the other end of the scale, single buildings can use CHP systems to generate their own electricity while providing thermal energy for internal uses. Between these two extremes, CHP is widely used in industrial facilities that have significant electricity and steam requirements *and* a ready source of fuel—for example, wood products companies and petroleum refineries. CHP systems are also increasingly used at multibuilding institutional facilities, such as universities and hospital complexes.

For single-building applications, CHP systems make the most sense where electric rates and electric demand charges are high. Sometimes opportunities for CHP can be found when the local utility company is looking to bolster its grid through distributed power production or when there is a need for greater reliability than the utility can provide. The best time to consider CHP for a facility is during the initial planning of new buildings and when major upgrades are planned for HVAC systems. Replacing electric chillers with absorption cooling or engine-driven chillers, for example, presents an excellent opportunity for CHP.

Technical Information

Thermal-energy losses from power plants in the U.S. currently total approximately 23 quads (one quad is 10^{15} Btu)—more than one-quarter of total U.S. energy consumption and equal to the total amount of energy spent on transportation.



Combined heat and power is compared with conventional power generation and heat production in this schematic. The total energy inputs required to produce 35 units of electricity and 50 units of heat are indicated for conventional electricity generation, boilers, and a cogeneration system. Cogeneration offers significant energy savings.

For CHP to succeed in buildings, two things are required: (1) an electricity-generation technology that produces excess heat, and (2) a use for the cogenerated heat.

Power-generation technologies that can be used on a small scale in CHP systems include advanced turbine systems, reciprocating spark-ignition (Otto cycle) engines, reciprocating compression-ignition (Diesel cycle) engines, microturbines, and fuel cells.

Practical uses for cogenerated thermal energy in buildings include direct space heating, water heating, absorption chillers, engine-driven chillers, desiccant dehumidification, compressed air, and industrial processes.

Total efficiencies of CHP systems can easily exceed 70%, and efficiencies as high as 90% have been achieved.

Regulatory and market hurdles for CHP include utility interconnection standards, high and often prohibitive utility charges for having backup power available

DOE/GO-102001-1165
NREL/BK-710-29267
May 2001

Photo: Massachusetts Institute of Technology

The air intake for the cogeneration plant at MIT in Cambridge, Massachusetts is pictured above. Waste heat from the gas turbine produces steam for the university.

In the late 1980s, the Massachusetts Institute of Technology (MIT) was spending $14 million per year on energy—oil and gas for their district-heating steam plant and electricity purchased from the local utility company. Facing rising electricity costs, growth in demand, and a need for more reliable power, MIT decided to install a CHP system. The 22-MW CHP system meets 94% of the university's electricity, heating, and cooling needs. It reduces annual energy costs by 40% and polluting emissions by 45%.

to facilities with on-site power production, unreasonably long depreciation standards for on-site generation, and environmental regulations that do not fairly take into account reductions in polluting emissions that occur beyond the plant being permitted.

Electric industry restructuring (deregulation) is expected to open up new opportunities for CHP by removing barriers that have existed in the current utility system.

The CHP Challenge announced by DOE in 1998 set a goal of doubling by 2010 the amount of U.S. power generated using CHP systems—an increase of 50 GW.

Energy service companies and energy service providers (ESPs) are becoming one-stop providers of heat and power—a trend that is likely to continue. ESCOs and ESPs simplify and reduce the risk of CHP development, particularly for larger projects.

The environmental benefits of meeting the CHP Challenge will include annual reductions of air emissions as follows: 150 million tons of CO_2, one million tons of SO_2, and one-half million tons of NO_X.

References

Combined Heat and Power, Special Supplement to *Energy Matters*, available online at www.oit.doe.gov/bestpractices/.

Elliott, R. Neal, and Mark Spurr, *Combined Heat and Power: Capturing Wasted Energy*, American Council for an Energy-Efficient Economy, Washington, DC, 1999. Executive summary available online, along with other reference materials, at aceee.org/chp/.

Combined Heat and Power: A Vision for the Future of CHP in the U.S. in 2020, U.S. CHP Association, 1999. Available online at www.nemw.org/uschpa/.

Buildings Cooling, Heating, and Power Vision, U.S. Department of Energy, 1999. Available online, along with other reference materials, at www.bchp.org.

Contacts

Office of Power Technologies, U.S. Department of Energy, Washington, DC; (202) 586-6074; www.oit.doe.gov/chpchallenge/ and www.eren.doe.gov/distributedpower/. Numerous fact sheets and reports available, as well as a Web-based software tool to help assess the feasibility of CHP systems for specific applications.

U.S. Combined Heat and Power Association, c/o Northeast-Midwest Institute, 218 D Street, SE, Washington, DC 20003; 202/544-5200; www.nemw.org/uschpa/ (includes links to major corporate stakeholders).

Distributed Power Coalition of America, 10 G Street, NE, Suite 700, Washington, DC 20002; (202) 216-5944; www.dpc.org.

Gas Technology Institute (formerly Gas Research Institute), 8600 W. Bryn Mawr Avenue, Chicago, IL 60631; (773) 399-8100; www.gri.org.